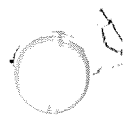


UNITED STATES DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
Region 5

R-5 FSH 2509.22

SOIL AND WATER CONSERVATION HANDBOOK



7/5/90

FOREST SERVICE HANDBOOK  
San Francisco, California

R-5 FSH 2509.22 - SOIL AND WATER  
CONSERVATION HANDBOOK

Region 5 Amendment No. 2

Effective July 16, 1990

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<u>Page Code</u>	<u>Superseded</u> <u>(Number of Sheets)</u>	<u>New</u>
00	1	1
50 thru 51.4--2	-	10

Digest:

50 - Adds chapter 50 which establishes guidelines for Soil Erosion Hazard Rating to meet FSM revision policy.

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Regional Forester



UNITED STATES DEPARTMENT OF AGRICULTURE  
FOREST SERVICE

SOIL AND WATER CONSERVATION HANDBOOK

Contents

CHAPTER

10	WATER QUALITY MANAGEMENT FOR NATIONAL FOREST LANDS IN CALIFORNIA - BEST MANAGEMENT PRACTICES (Reserved)
20	CUMULATIVE OFF-SITE WATERSHED EFFECTS ANALYSIS
30	STREAMSIDE MANAGEMENT ZONES
40	RIPARIAN AREA MANAGEMENT
*- 50	SOIL EROSION HAZARD RATING

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## SOIL AND WATER CONSERVATION HANDBOOK

## CHAPTER 20 - CUMULATIVE OFF-SITE WATERSHED EFFECTS ANALYSIS

Contents

## ZERO CODE

20.1	Authority
20.2	Objective
20.3	Policy
20.4	Responsibility
20.5	Definitions
20.8	References (Interim Directive)
21	FOREST SERVICE INTERNAL USE
21.1	Internal Use
21.2	Mixed Ownership Watersheds
22	MODEL
22.1	Overview
22.11	Cumulative Off-Site Watershed Effects
22.12	State of the Art and Practice
22.2	Conceptual Model
22.21	Assumptions
23	PROCEDURE
23.1	Overview
23.2	Beneficial Uses of Water
23.21	Water Quality Protection Criteria
23.3	Watershed Size
23.4	Watershed Characteristics
23.41	Climate
23.42	Hillslope and Stream Channel Attributes
23.5	Mechanics for Initiating CWE
23.6	Watershed History
23.61	Natural Watershed Sensitivity
23.62	Watershed Tolerance to Land Use
23.63	Land Disturbance
23.63a	Site Disturbance
23.63b	Mitigation Measures
23.63c	Site Recovery
23.63d	Land Use History
23.63e	Current Watershed Disturbance
23.7	Proposed Land Use
23.8	CWE Susceptibility Evaluation
23.9	Documentation
24	MONITORING AND EVALUATION
24.1	Implementation Monitoring
24.2	Effectiveness Monitoring
24.3	Validation Monitoring

SOIL AND WATER CONSERVATION HANDBOOK

CHAPTER 20 - CUMULATIVE OFF-SITE WATERSHED EFFECTS ANALYSIS

25	IMPLEMENTATION
25.1	Organizational Structure
25.2	Wild Fire
25.3	Northern Sub-Region
25.31	Analysis Areas
25.32	Natural Watershed Sensitivity
25.33	Land Disturbance
25.34	Site Recovery
25.4	Central Sub-Region (Reserved)
25.5	Southern Sub-Region (Reserved)



## SOIL AND WATER CONSERVATION HANDBOOK

## ZERO CODE

This chapter describes the cumulative off-site watershed effects (CWE) assessment procedure used on National Forest System (NFS) lands within the State of California. Known information used in the analysis produces an objective, reproducible, and professional assessment of the combined effects of all past, present and reasonably foreseeable future management actions on downstream beneficial uses of water. Application of the procedure is guided by a conceptual CWE model. Both the model and procedure are refined and modified as results of monitoring and technical studies become available.

This chapter limits the scope of the methodology to only evaluating the susceptibility of CWE on downstream beneficial uses of water. The procedure is useful for evaluating both beneficial and adverse CWE. Beneficial effects may result from management actions such as watershed improvement projects and special project mitigation. Adverse effects may result from multiple land uses activities which combine to cause detrimental changes in watershed hydrology or sedimentation from landsliding and soil erosion.

The procedure described in this chapter is similar to decision making models which use relative rankings and weightings (for example, Kepner-Tregoe, 1973). Known information about natural processes and land use effects is used to evaluate CWE susceptibility as part of the environmental analysis process (FSH 1909.12; FSH 1909.15; FSM 1910, 1920 & 1950). Its purpose is to:

1. Assist forest managers in scoping issues and concerns during planning and to identify areas that require additional evaluation of CWE-related issues.
2. Identify beneficial uses of water and watershed, climatic and land use factors that combine to influence the identified beneficial uses.
3. Use existing information to assess the influence of multiple land use activities on beneficial uses of water.

Analysis of cumulative watershed effects is a young and expanding field. Although knowledge of the subject is limited, enough is known to develop reasonable estimates of CWE susceptibility. Given the limits of current knowledge, application of the procedure requires considerable professional judgement. It is important that an interdisciplinary team conduct the assessment and that the team's professional judgement temper any formulas or numbers the team develops.

## SOIL AND WATER CONSERVATION HANDBOOK

20.1 - Authority. The principal Federal laws influencing the Forest Service's efforts to evaluate CWE include the following:

1. Organic Administration Act of June 4, 1897. This Act emphasizes that the National Forests were created to improve and protect the forest within the boundaries; to secure favorable water flows; and to furnish a continuous supply of timber for the use and necessities of the citizens of the United States.
2. National Environmental Policy Act (NEPA) of January 1, 1969. NEPA promotes efforts which will minimize environmental damage and develop an understanding of the interrelationships of all components of the natural environment and the effects of human activities on the environment. It requires that direct, indirect and cumulative effects be considered when conducting an environmental analysis.
3. Clean Water Act of 1972, as amended in 1977 and 1980. Section 208 of the Clean Water Act required the States to prepare non-point source pollution plans which were to be certified by the State and approved by the Environmental Protection Agency (EPA). In response to this law, and in coordination with the State of California Water Resources Control Board (SWRCB) and EPA, Region 5 began developing Best Management Practices (BMP) for water quality management planning on National Forest System lands within the State of California in 1975. This process identified the need to develop a BMP for addressing the cumulative off-site watershed effects of forest management activities on the beneficial uses of water.

20.2 - Objective. This chapter sets forth guidance for evaluating CWE susceptibility resulting from forest management activities.

20.3 - Policy. It is Region 5 policy to address cumulative watershed effects in Regional, Forest and project planning and to initiate mitigation measures to minimize the risk of significant, adverse impacts on beneficial uses of water.

20.4 - Responsibility

1. Regional Forester. Develop and document a procedure for assessing CWE potential that has Region-wide application. Conduct training in applying and monitoring the procedure. Exercise quality control of Forests' analysis of CWE.
2. Forest Supervisor. Assess and evaluate CWE during Forest Land and Resource Management Planning. Develop and document standards and guidelines in Forest Land and Resource Management Plans for evaluating and monitoring CWE during Forest Plan implementation.

## SOIL AND WATER CONSERVATION HANDBOOK

20.5 - Definitions

## 1. Abbreviations.

BMP - Best Management Practices

CRM - Coordinated Resource Management Plan

CWA - Clean Water Act

CWE - Cumulative Off-Site Watershed Effects

EA - Environmental Analysis

EPA - Environmental Protection Agency

ERA - Equivalent Road Acres

FSH - Forest Service Handbook

FSM - Forest Service Manual

ID - Interdisciplinary

NEPA - National Environmental Policy Act

NFS - National Forest System

RRP - Resource Recovery Program

SWRCB - State Water Resources Control Board

TOC - Threshold of Concern

## 2. Glossary of Terms

Beneficial Use. A use of the waters of the State including but not necessarily limited to domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetics; navigation; and protection and enhancement of fish, wildlife, and other aquatic resources or preserves.

Best Management Practice (BMP). A practice or a combination of practices, that is determined by a State (or designated area-wide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and

## SOIL AND WATER CONSERVATION HANDBOOK

institutional considerations) means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals. BMPs are certified by the SWRCB and approved by EPA, in compliance with Section 208 of the Clean Water Act (P.L. 92-500).

Cumulative Impacts. The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7).

Cumulative Off-site Watershed Effects (CWE). All effects on beneficial uses of water that occur away from the locations of actual land use which are transmitted through the fluvial system. Effects can be either beneficial or adverse and result from the synergistic or additive effects of multiple management activities within a watershed.

Extremely Unstable Lands. Areas highly susceptible to landsliding. Land areas exhibiting one or more of the following characteristics are examples of extremely unstable lands:

- a. Active landslides.
- b. Valley inner gorge.
- c. Portions of shear zones and dormant landslides having slope gradients greater than about 60 percent to 65 percent.
- d. Slopes underlain by unconsolidated deposits where the slope gradients are at or steeper than the angle of repose of the materials. The angle of repose is commonly between 60 and 75 percent for deposits such as stream terrace deposits, glacial moraines, and colluvial deposits.
- e. Previously unfailed lands determined to be marginally stable, based on principles of soil and rock mechanics or previous experience with similar lands.

Forest Planning. Forest-wide land and resource management planning (FSM 1906.13a).

## SOIL AND WATER CONSERVATION HANDBOOK

Interdisciplinary (ID) Team. A group of two or more individuals with different training assembled to solve a problem or perform a task. The team is assembled out of recognition that no one scientific discipline is sufficiently broad to adequately solve the problem. The members of the team proceed to solution with frequent interaction so that each discipline may provide insights to any stage of the problem and disciplines may combine to provide new solutions.

Project Planning. Project planning deals with how a particular project will be designed and implemented. The degree of planning varies according to the complexity of the project (FSM 1906.21).

Riparian. In general terms, the land bordering a stream, lake or tidewater.

Riparian Area. A geographically delineated area with distinctive resource values and characteristics that is comprised of the aquatic and riparian ecosystem.

Riparian Ecosystem. The transition area between the aquatic ecosystem and terrestrial ecosystem, identified by soil characteristics and distinctive vegetation communities that require free or unbound water.

Valley Inner Gorge. A geomorphic feature consisting of the unbroken slope adjacent to a stream channel which usually has a slope gradient of 65 percent or greater. The inner gorge is identified as the area of channel side slope situated immediately adjacent to the stream channel and extending upward to the first break in slope above the stream channel.

Debris sliding and avalanching, which are the dominant mass wasting processes in this zone, may result from recent oversteepening of the inner gorge zone by stream incision as well as from reactivation of rotational-translational slide toe zones within the inner gorge.

## 21 - FOREST SERVICE INTERNAL USE

21.1 - Internal Use. Use the CWE analysis to address off-site effects of multiple land use activities on beneficial uses of water. When applying this analysis assume that implementation of BMPs will mitigate on-site impacts of activities on water quality.

21.2 - Mixed Ownership Watersheds. Evaluating CWE in watersheds of mixed ownership may present a difficult and complex management situation. Often, actions of non-Forest Service landowners are unknown so scheduling of National Forest System (NFS) land use activities to minimize the risk of incurring adverse CWE is

## SOIL AND WATER CONSERVATION HANDBOOK

uncertain. When considering management options in mixed ownership watersheds, current Forest Service strategy is to apply them on the basis of the percentage of land ownership, thus proportioning the amount of disturbance contributed by any one ownership.

Forest Service managers should work with other landowners and managers to develop Coordinated Resource Management Plans (CRM) for watersheds where CWE have the potential to result in irreversible and irretrievable impacts to beneficial uses of water. In the absence of a CRM, managers should make a reasonable effort to obtain planning-level land use information from other landowners and managers. Failing the formulation of a CRM and acquisition of needed information from other owners, managers should use knowledge of historic use, trends and best professional estimates to forecast future actions on other lands. In the absence of any information, managers may have to assume that all lands of other ownership are completely disturbed to the maximum extent. This will establish a "heavy disturbance" scenario, so that when including proposed forest activities, managers can state that CWE is expected to either occur or not occur.

## 22 - MODEL

22.1 - Overview. Any model for evaluating CWE needs to identify what the concerns are and recognize limitations in the current scientific understanding of the problem. It must also bring together what is currently known about assessing the problem in a way that is flexible to local conditions and able to incorporate new information.

Limitations in the state of the art precludes development of a quantitative, process-based model to predict the absolute potential for CWE. Experience indicates that CWE susceptibility is best evaluated using conceptual models. These models attempt to predict the degree of risk of initiating adverse CWE by providing a framework in which to assemble relevant knowledge necessary to answer the following questions:

1. What are the beneficial uses of water and where do they occur?
2. What are the important factors influencing those uses?
3. How might multiple management activities affect the beneficial uses?
4. Where and under what circumstances will CWE occur?

## SOIL AND WATER CONSERVATION HANDBOOK

5. How can CWE be mitigated?

6. How long will it take for an adversely impacted use to recover to within acceptable limits?

The intent of the model is to estimate the potential for CWE by utilizing current knowledge and experiences in other watersheds having similar characteristics. The model presented in this chapter is one method of bringing together knowledge and experiences relevant to assessing CWE. It requires an interdisciplinary team of resource staff to estimate CWE susceptibility. This estimate is based on their, and others, combined experiences and knowledge.

The model first approximates the importance of CWE and helps identify possible cause and effect relationships influencing CWE. The approximations are revaluated and modified, as required, as new information becomes available from monitoring, field experiences and published studies. Use of the model in this manner provides an objective, reproducible and rational evaluation of CWE in forest and project planning.

22.11 - Cumulative Off-Site Watershed Effects. In the context of this chapter, CWE is the concern being assessed. CWE includes all effects on beneficial uses of water that occur away from the locations of actual land use and are transmitted through the fluvial system. CWE impacts result from the combined effects of multiple management activities within a watershed. Individual effects can combine linearly or nonlinearly to produce undesirable downstream CWE.

Cumulative effects may result from changes in watershed hydrology, sedimentation rates (landsliding and/or surface soil erosion) and water temperature or chemistry that result from multiple land management activities. Procedures described in this chapter are best suited for monitoring changes in watershed hydrology and sedimentation rates.

Indicators of CWE vary, depending upon watershed characteristics, climatic regime and water-related values of concern. For example, in areas where fish habitat is the primary concern, changes in channel morphology or aquatic biologic diversity may be primary indicators that unacceptable changes are occurring.

Unacceptable CWE can be manifest over different time frames. For example, sediment may be introduced and routed through the system soon after a group of land disturbing activities have occurred. This may result in a short-term reduction in aquatic habitat quality, drinking water quality or some other beneficial use. In another situation

## SOIL AND WATER CONSERVATION HANDBOOK

unacceptable CWE may not be manifest for a number of years following intensive land use in a watershed. In this case initiation of CWE may occur only after a triggering climatic event. Impacts resulting from this event may cause significant and long-term reduction in fish habitat and other beneficial uses.

22.12 - State of the Art and Practice. Modeling CWE is not a precise science; it is a young and developing field. Development of a quantitative, statistically valid, technical model for assessing CWE is not now possible because ecological and geomorphic systems are complex and vary from one watershed to another. No one technical model will reasonably simulate all variables for all ecological and geomorphic systems. Adding to the complexity of the situation are limitations in understanding geomorphic processes in mountainous terrain and influences of climate and human activities on process rates and resulting impacts to down stream beneficial uses of water.

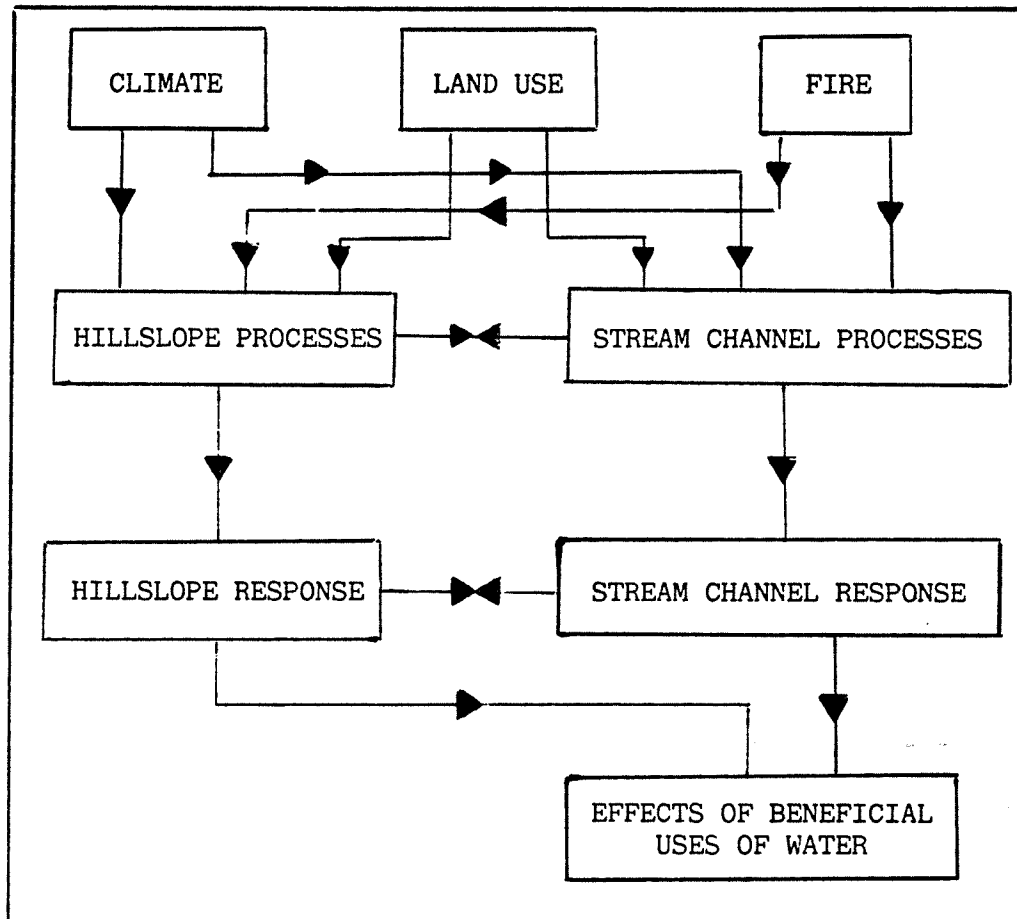
Recent studies demonstrate that it is possible to estimate CWE susceptibility by identifying and monitoring important variables (for example, Farrington & Savina (1977), Seidelman, et al. (1977), Coats & Miller (1981), Wolfe (1982), Haskins (1983), Lyons & Beschta (1983), Grant, et al. (1984)). Results of these types of studies and our own experiences working with forest management issues lead to the conclusion that the following variables, at least, need consideration in an integrated manner when evaluating CWE:

1. Beneficial uses of water.
2. Hillslope and stream channel characteristics.
3. The nature, amount and location of geomorphically and biologically sensitive lands within each watershed.
4. Type, location, extent and timing of management disturbances within each watershed.
5. The nature, location and extent of land disturbing activities relative to sensitive lands.
6. Cause and effect relationships of human activities and climatic events on beneficial uses of water.

22.2 - Conceptual Model. Occurrence of adverse CWE results from the interaction of many related variables. These include: beneficial uses of water; geology; watershed geomorphology and hydrology; soils; climate; wild fire and land use. Exhibit 1 is a flow diagram that depicts the conceptual model for the relative relationships of these major variables.



## SOIL AND WATER CONSERVATION HANDBOOK

EXHIBIT 1

## SOIL AND WATER CONSERVATION HANDBOOK

22.21 - Assumptions. The procedure described in section 23 is based on conceptual model described in section 22.2 and the following assumptions:

1. Beneficial uses of water can be identified and acceptable degradation limits established for each use.
2. Key indicators of unacceptable degradation can be identified for each use or value and these indicators monitored over time.
3. For a given hydrologic event, or sequence of events, an upper limit of tolerance to disturbance exists for each watershed. The risk of initiating adverse CWE greatly increases as this upper limit is approached and exceeded. The upper limit of tolerable disturbance may represent a geomorphic, biologic, management or legal threshold.
4. Traditional management practices can cause severe adverse impacts when applied to sensitive lands through human error, misunderstanding, or incomplete knowledge of the landscape.
5. The potential for initiating adverse CWE can be reduced by:
  - a. Limiting management practices on highly sensitive lands to those required to maintain or improve water quality and land stability.
  - b. Dispersing land disturbing activities in time and space.
  - c. Controlling the physical size, shape, location and timing of land disturbing activities (for example, timber harvest units, prescribed burn areas).
  - d. Implementing other BMPs to mitigate adverse on-site effects.
6. In most cases, watersheds will not reach or exceed an upper limit of tolerable disturbance, provided that assumption 5 is reasonably implemented.

## 23 - PROCEDURE

23.1 - Overview. This procedure is based on the model and assumptions described in section 22. Use this procedure to use known information when evaluating CWE susceptibility in the decision-making process. Its application is similar to that of other decision making models (for example, Kepner-Tregoes, 1973) for which finite information is not available. Known information is compiled and evaluated. Significant factors are identified and given numerical ratings based on their relative importance. The results of weighting and adding

## SOIL AND WATER CONSERVATION HANDBOOK

these numerical values is used to represent differences in alternatives. Often an iterative process is used to adjust these numerical values, based on professional judgement, until the output of the model best represents observed conditions.

Physical, biologic, climatic and land use factors are identified and evaluated based on their relative importance. For example, land use practices are given numerical disturbance values, relative to the nature and degree of land disturbance and the probable mechanism for initiating CWE. These values are then decayed over time to reflect the rate at which the disturbed sites recover to their natural condition.

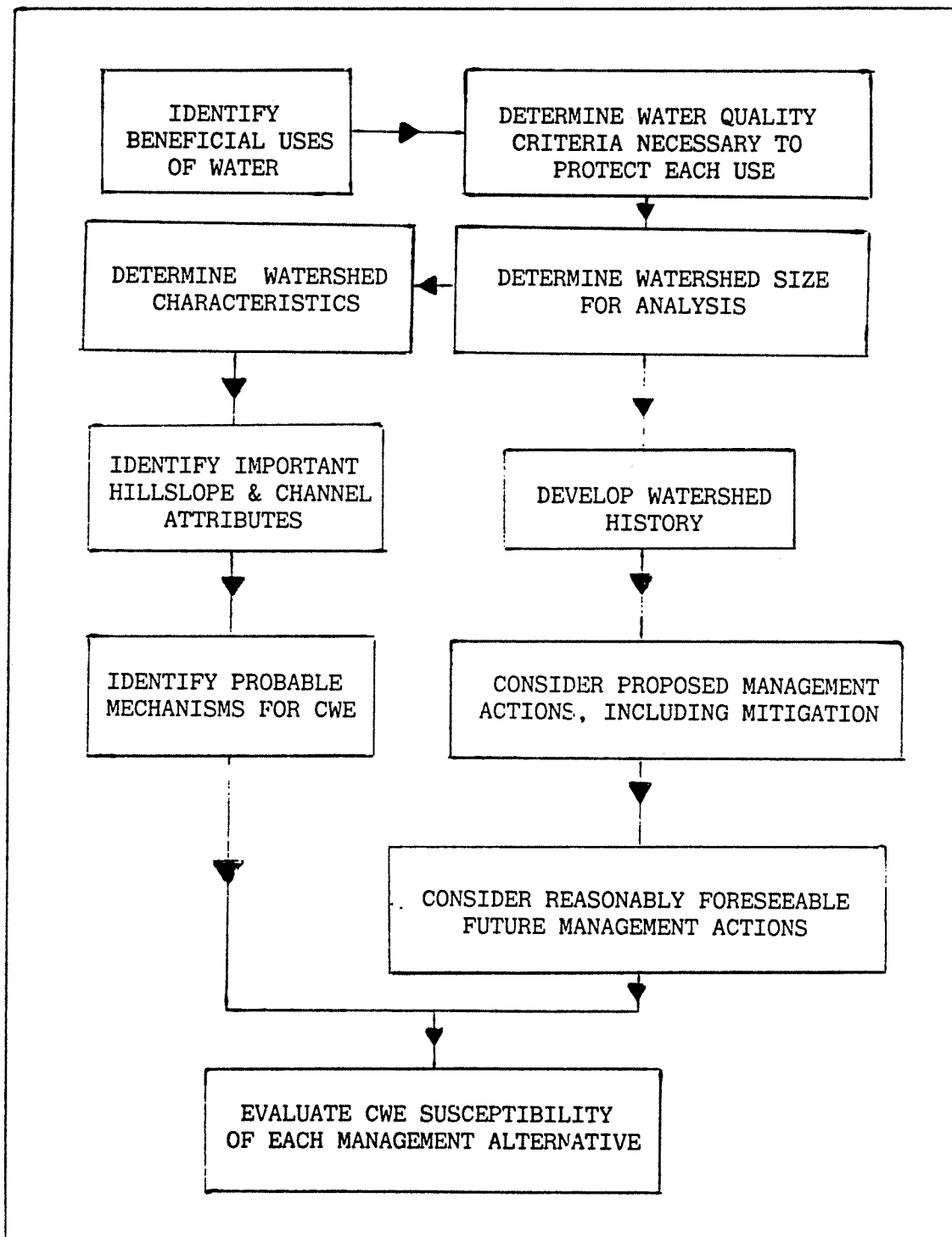
Changes in land disturbance levels over time are tracked through an accounting system that keeps track of these changes in numerical values. Watershed boundaries delineate the basic area of analysis. Haskins (1986) discusses implementation of the model for use on the Shasta-Trinity National Forests for identifying, rating and monitoring these factors.

Estimating the ability of watersheds to tolerate land use activities is made by observing watersheds with similar physical and biologic characteristics and which are subjected to similar climatic conditions. These observations are made using a variety of information including aerial photography, stream channel inventories, land use history (including changes in management practices over time), resource inventories, and other relevant information.

Upper limits of watershed tolerance to land use are estimated. This upper disturbance limit is called the Threshold of Concern (TOC). It is estimated by grouping watersheds with similar characteristics, then identifying watersheds where down-stream beneficial uses of water have definitely been adversely impacted and those where the uses have definitely not been adversely impacted. The first approximation of the TOC is then made, by professional judgement, somewhere between the two limits. Future field investigations, published studies and the results of long-term monitoring are used to reevaluate and modify these initial estimates.

The procedure for evaluating CWE susceptibility requires consideration of factors shown in Exhibit 1.

## SOIL AND WATER CONSERVATION HANDBOOK

EXHIBIT 1

## SOIL AND WATER CONSERVATION HANDBOOK

23.2 - Beneficial Uses of Water. The first step in evaluating CWE is to determine which downstream beneficial uses of water might be affected by multiple management activities and where each occurs in the channel system. Examples of downstream values include:

1. Aquatic habitat.
2. Recreation.
3. Water supply.
4. Flood control.
5. Reservoir storage.
6. Power generation.

23.21 - Water Quality Protection Criteria. Determine protection criteria for each identified beneficial use. Identify indicators of unacceptable disturbance for each use.

23.3 - Watershed Size. Watershed boundaries form the basic area of analysis regardless of land ownership patterns or administrative boundaries. It is necessary to conduct the CWE evaluation on entire watersheds as changes in fluvial morphology and resulting impacts on beneficial uses of water result from the interaction of activities on all lands within the watershed.

Appropriate watershed sizes for analysis are determined by resource staff conducting the CWE evaluation. Use information about the nature of the project, beneficial uses of water and watershed characteristic to guide selection of watershed size. Experience to date suggests that fourth and fifth order watersheds commonly form analysis areas for forest planning while second and third order watersheds are often evaluated for project planning. Other important considerations include project size and special project characteristics.

23.4 - Watershed Characteristics. Identify and describe physical and biological watershed attributes, and their relationships, to develop a general understanding of the watershed system and factors that may influence watershed response to land use. This information is also useful for identifying general similarities and differences between groups of watersheds, and for determining the types of investigations necessary when considering CWE.

As a minimum, characterize watersheds in terms of their climate, hillslope and stream channel geomorphology, hillslope and stream channel hydrology, soils, geology, and physically and biologically sensitive land units.

23.41 - Climate. Climate influences watershed response to land use. There are several variables to consider when characterizing the climate of an area. However, in a given locale it is often possible to identify and consider certain key climatic factors. Experiences to date indicate that key factors often include climatic regime, annual precipitation and intensity and duration of precipitation. Climatic regimes are broadly identified as rain-dominated, snow-dominated or rain-on-snow (transient snow zone).

Determine key climatic factors. Climatic regime is a basic factor to be considered in all watersheds. Watershed specific concerns will guide determining which other factors are key. For example, precipitation patterns and intensities are important in watersheds containing landslides. In addition, certain climatic events may prove to be important factors.

Factors that influence selection of significant, or indicator, climatic events include: watershed morphology, stream channel sensitivity, beneficial uses of concern and the ability of the hillslope and stream channel to experience the event without significantly impairing water quality values.

23.42 - Hillslope and Stream Channel Attributes. Geomorphic, biologic and hydrologic attributes of hillslopes and stream channels often provide sensitive indicators of watershed response to land use. In addition, it may be possible to apply knowledge of attribute response to climate and land use in one area to other, similar areas where direct information is not available.

Use existing inventories to identify important hillslope and stream channel characteristics. For watersheds where inventories and surveys are incomplete, use knowledge of watersheds with similar geomorphic and hydrologic attributes to estimate important relationships. Conduct additional inventories and surveys, as required, to develop needed information.

Use the following types of inventories and sources of information for identifying and evaluating hillslope processes:

1. Geologic Resource Inventory (FSM 2880)
2. Landslide identification and analysis (for example: Sidle, et al, 1985; Varnes, 1978)
3. Soil Resource Inventory (FSH 2509.18)
4. Ecosystem Classification (FSH 2090.11)

## SOIL AND WATER CONSERVATION HANDBOOK

Use the following types of information and inventories to evaluate channel processes by:

1. Stream channel classification based on morphological characteristics (Rosgen, 1985)

2. Current channel condition (Pfankuch, 1978)

Riparian ecosystems are often associated with streamside areas that form the boundary between hillslopes and stream channels. They can, however, occur at almost any area within a watershed system. For these reasons, riparian areas may not be adequately considered when using the types of inventories, surveys and information listed above. Use Riparian Area Management (Chapter 40) and other guidelines to identify riparian area attributes.

23.5 - Mechanics for Initiating CWE. Use information developed from sections 23.2 and 23.5 to identify possible mechanisms for initiating CWE, including:

1. Changes in hillslope and stream channel hydrology.
2. Chronic sedimentation.
3. Pulse sedimentation.
4. Changes in woody debris.

The dominant mechanism may change with location in the stream channel system. These changes may result from either changes in beneficial uses or channel characteristics. For example, changes in watershed hydrology and woody debris may be the dominant mechanisms in steep, first to third-order channels containing significant inner gorge reaches; changes in sediment budget and routing may be the dominant mechanisms in low gradient third-order, and larger channels in the same system.

Identification of the most probable mechanism(s) for CWE allows investigators to ask questions and refine the conceptual model and procedure to focus on important physical and biological relationships and concerns.

23.6 - Watershed History. Develop a watershed history of land use and significant natural events. Review historical records for all past land use activities and natural events occurring in the watershed, regardless of land ownership or administrative boundaries.

Land use information should disclose, as a minimum: the activity, when and where it occurred, estimates of initial site impacts and time necessary for the site to recover to its natural condition.

## SOIL AND WATER CONSERVATION HANDBOOK

Information needed for natural events such as wild fire, landsliding and major storms is similar to that required for land use activities. It may, however, be necessary to use information from outside the watershed to estimate frequency and magnitude of occurrence for the natural events.

Relate, if possible, changes in watershed disturbance to changes in hillslope and stream channel condition and resulting impacts on down-stream, beneficial uses of water.

23.61 - Natural Watershed Sensitivity. Natural watershed sensitivity is an estimation of a watershed's natural ability to absorb land use impacts without increasing CWE susceptibility to unacceptably high levels. The measure of susceptibility to CWE may be a geomorphic or biologic threshold, or some more restrictive management or legal limit.

In general, natural watershed sensitivity to land use increases as the percentage of sensitive lands and stream channels in the watershed increases. Examples of highly sensitive land units include:

1. Active landslides.
2. Portions of dormant landslides.
3. Valley inner gorge.
4. Riparian areas.
5. Meadows.
6. Slopes greater than 80 percent.
7. Very highly erodible soils.

Other land generally considered sensitive but having less influence on watershed sensitivity include:

1. Non-riparian ephemeral drainages.
2. Soil covered areas immediately down slope from rock out crops.
3. Areas near active landslides and valley inner gorges.
4. Slopes between 60 and 80 percent.
5. Highly erodible soils.



## SOIL AND WATER CONSERVATION HANDBOOK

Land units do not contribute equally to natural sensitivity. Location of sensitive lands within the watershed also influences watershed sensitivity. Use professional judgement to determine the relative importance of each attribute when estimating watershed sensitivity. For example, the more sensitive land units may be given a weighted importance 2 to 10 times greater than other, less significant units. The ID team sets the weights based on available information, field observations and aerial photo interpretation. See Haskins (1986) for an example of how to select and weigh these attributes.

Use information gathered in sections 23.4 through 23.6 to estimate natural watershed sensitivity. Give special consideration to stream channel sensitivity as determined by stream channel classification (Rosgen, 1985) and landslide inventory (FSM 2880).

Estimate the sensitivity of watersheds relative to one another. Do this by grouping together watersheds having similar climatic, physical and biologic attributes and which have similar amounts of sensitive land units. Compare and rank the watershed groups into high, moderate and low sensitivity classes. Use the following process to approximate the relative sensitivity of one watershed to another, and one group of watersheds to another:

1. Map land units according to their physical and biologic attributes.
2. Evaluate stream channel morphology and sensitivity.
3. Establish relative weights of the importance of each attribute regarding sensitivity to disturbance from land use.
4. Multiply the percentage of various attributes (land unit acreage/total watershed acres) by the relative weight.
5. Accumulate the weighted extent of the attributes for each watershed. The watershed with the largest accumulated value has the greatest natural sensitivity to disturbance.
6. Group together watersheds having similar climate, stream channel characteristics and natural sensitivity values. For general planning purposes, rank the groups of watersheds into high, moderate or low natural sensitivity classes.

Geomorphic and climatic processes vary widely throughout Region 5. Therefore, generally confine grouping of watersheds to reflect relative sensitivity, to geographic areas that fit local needs.

## SOIL AND WATER CONSERVATION HANDBOOK

23.62 - Watershed Tolerance To Land Use. Watersheds with a high natural sensitivity can tolerate less land disturbance and require greater care in planning land use activities than watersheds with a low sensitivity. As the amount of land use increases within a watershed, the susceptibility of that watershed to CWE increases. There is a point where additive or synergistic effects of the land use activities will cause the watershed to become highly susceptible to CWE.

Estimate the upper limit of watershed tolerance to externally applied factors such as climate and land use. This upper tolerance limit is influenced by the extrinsic effects of both climate and land use. Address climatic effects by:

1. Considering climatic influences on watershed processes (section 23.4).
2. Using known information regarding climatic influences of watershed response to land use impacts.
3. Holding climatic influences relative constant by requiring only watersheds with similar climate be grouped together for comparative analysis (sections 23.4 and 23.61).

Impacts resulting from land use then become the primary extrinsic variable tracked. This estimated upper limit to land use is called the Threshold of Concern (TOC). Estimate the TOC by comparing land use histories and resulting impacts on beneficial uses in similar watersheds. Estimating the TOC is an iterative, multi-stepped process that includes:

1. Determining natural watershed sensitivity as described in section 23.61.
2. For each group of watersheds identified in section 23.61, Item 6:
  - a. Establishing land use history as described in section 23.63.
  - b. Observing adverse changes in stream channel condition and resulting effects on beneficial uses of water.
  - c. Identifying watersheds where significant, adverse CWE have definitely occurred and those where CWE have definitely not occurred. Characterize land disturbance history for each group of watersheds in terms of disturbance coefficients (section 23.63) and narrative explanations of the observed cause-effect relationships. Also document any observations and other information regarding recovery rates of both on-site and off-site, downstream impacts.

## SOIL AND WATER CONSERVATION HANDBOOK

3. Use information developed in Items 1 and 2 to estimate TOC. The TOC for each group of watersheds will occur somewhere between the two limits established in Item 2c. Use professional judgement to make the initial estimate of where the TOC lies between those two limits.

The TOC does not represent the exact point at which cumulative watershed effects will occur. Rather, it serves as a "yellow flag" indicator of increasing susceptibility for significant adverse cumulative effects occurring within a watershed. Susceptibility of CWE generally increases from low to high as the level of land disturbing activities increase towards or past the TOC.

4. Adjust TOC estimates, as required, based on new information and monitoring results.

23.63 - Land Disturbance. Land use activities often result in the alteration of natural physical and biological watershed attributes. The nature, severity and persistence of site disturbance resulting from a land use activity is often difficult to quantify because it is a function of the land use activity, where it occurs and how well the activity is done. This difficulty in quantification is especially true when one type of activity is compared with another (for example, timber harvesting, summer residences, grazing and camping).

It is for this reason that normalized, numerical disturbance coefficients are used to track overall land disturbance within watersheds. The coefficients are estimates of land disturbance as they relate to probable mechanisms for initiating CWE (section 23.5) and resulting impacts to downstream, beneficial uses. They provide a standardized unit of measure for comparing the land disturbing effects of a wide range of land use activities.

23.63a - Site Disturbance. Develop normalized numerical disturbance coefficients to estimate land disturbance resulting from existing and proposed land use activities. These coefficients are estimates of the effects of land disturbance as it relates to alteration of hillslope and stream channel attributes and the influence those alterations have on identified mechanisms to initiate CWE.

Estimation of land disturbance coefficients relies on interdisciplinary professional judgement. Use techniques such as visual observation, field surveys, published studies, transects and aerial photo interpretation to estimate land disturbance coefficients.

Develop coefficients that reflect modification of:

1. Woody debris attributes, when identifying changes in woody debris as a probable mechanism for initiating CWE.

## SOIL AND WATER CONSERVATION HANDBOOK

2. Hillslope stability and sediment budgets and routing, when identifying pulse or chronic sedimentation as probable mechanisms for initiating CWE.

3. Compacted surface, interception of groundwater, changes in groundwater recharge or storage, and efficiency in water delivery to stream channels when identifying alteration of watershed hydrology as a probable mechanism for initiating CWE.

23.63b - Mitigation Measures. Consider the effectiveness of mitigation measures in reducing the susceptibility of adverse CWE. The effectiveness of mitigation measures is reflected in initial disturbance coefficients, recovery rates and narrative documentation of CWE analyses.

Mitigation measures are accomplished in one of two ways. The first is during project planning, design and implementation. This type of mitigation, includes avoidance of problem areas and, as it relates to beneficial uses of water, application of BMPs during project design and implementation. Appropriate BMPs are identified during environmental assessment and designed based on site-specific concerns and objectives. Numerous mitigation measures can be employed to individual management practices to lessen both site-specific impacts and CWE susceptibility. The following are some examples:

1. Increasing width of stream management zones.
2. Temporarily closing and revegetating system roads.
3. Placing slash along fill slopes near stream management zones to intercept sediment from the road prism.
4. Cool burning timber harvest slash rather than piling and burning or using a hot burn.
5. Outsloping the road bed to disperse surface runoff rather than concentrating runoff in inside road ditches.

Remedial measures constitute the second group of mitigation measures. The objectives of these measures are to repair site specific problems, improve overall watershed condition and reduce CWE susceptibility. Landslide stabilization, road drainage improvement, obliteration of roads, and timber stand reforestation are examples of remedial measures that tend to reduce CWE susceptibility and improve watershed recovery. Construction of these projects is also an effective way to reduce existing site disturbance.

Modify site disturbance coefficients to reflect the quality of BMP implementation and the effects of constructed remedial measures.

## SOIL AND WATER CONSERVATION HANDBOOK

23.63c - Site Recovery. Areas disturbed by land use often tend to return to their natural (undisturbed) state over time. Recovery rates are variable and dependent upon many factors, including the type and extent of disturbance, soils, climate, rate of revegetation and rate of dechannelization of water from roads, skid trails and cable corridors.

Site recovery generally occurs in a nonlinear manner. A considerable percentage of recovery may occur during the first few years after completion of the land-disturbing activity. In other situations, however, sequential management activities may cause increasing disturbance levels for a few years before site recovery may begin. The lack of data required to develop accurate curves limits the use of nonlinear curves.

The ID team develops site recovery curves. The team bases its first approximation of site recovery rates on experience and consideration of factors such as rate of dechannelization of artificially channelized water, percent area in vegetative cover, presence or absence of hydrophobic soils, and other local factors of importance. The ID team shall use future field evaluations and results of monitoring to modify their first approximations.

23.63d - Land Use History. Develop land use history by reviewing historical records for all past activities in the watershed, regardless of land ownership or administrative boundaries. It is sometimes not possible, or even essential, to develop a detailed, highly accurate management history. In these instances, studying available resource aerial photography (scales of 1:15,840 & 1:24,000) taken over the past 20 to 30 years generally provides the detail of information required to conduct the analysis.

23.63e - Current Watershed Disturbance. Develop an estimate of current watershed disturbance by assigning forest-developed site disturbance coefficients to each identified land use. Consider changes in forest practices that have occurred over time when developing and assigning disturbance coefficients. Use site recovery curves and effects of mitigation to decay initial site disturbance over time to determine current watershed disturbance.

23.7 - Proposed Land Use. Identify the proposed land uses considered in the environmental analysis. Determine watersheds where the proposed activities are to occur. Using information previously developed, delineate watershed boundaries for CWE analysis (section 23.3). Use planning records and other appropriate information (section 21.2) to identify reasonably foreseeable future land uses in the watersheds to be analyzed.

## SOIL AND WATER CONSERVATION HANDBOOK

Use known information to estimate land disturbance resulting from each of the proposed actions. Estimate the nature, extent and duration of disturbance of each proposed action.

23.8 - CWE Susceptibility Evaluation. Use information developed in section 23 to evaluate existing and potential CWE susceptibility of each proposed action. As previously explained, evaluation of CWE susceptibility is based on what is known about the study watershed and other watersheds with similar physical, climatic and biological characteristics.

Explain CWE susceptibility in terms of existing and potential future impacts on beneficial uses. Identify possible modifications of land use plans and remedial measures to mitigate existing or potential adverse CWE.

23.9 - Documentation. Document the CWE evaluation performed as part of the environmental analysis for forest and project planning. Do not rely solely on disturbance coefficients and TOC values when discussing existing or potential CWE impacts.

Documentation can take one of two forms. The first is a simple statement that, based on comparison of existing and potential disturbance coefficients with TOC, CWE susceptibility is not a concern requiring additional consideration in the environmental assessment process. Add to this statement a brief narrative explanation of how and why that conclusion was reached.

More extensive documentation is required when comparison of disturbance coefficients and TOC indicate that CWE is a concern. As a minimum, describe factors considered in sections 23.2 through 23.7, differences in CWE susceptibility between management alternative and recommendations for mitigation measures to reduce CWE potential.

In both situations, the narrative developed needs to answer the following types of questions:

1. What are the beneficial uses of concern?
2. Where do the important beneficial uses occur?
3. How has or might land use affect those uses?
4. What are the important climatic, physical and biological factors influencing CWE of beneficial uses?
5. How significant will downstream effects be?
6. Where will they take place?

## SOIL AND WATER CONSERVATION HANDBOOK

7. Under what circumstances will they occur?

8. How long will it take the channel system and beneficial uses to recover?

24 - MONITORING AND EVALUATION. Conduct monitoring and evaluation to determine if CWE model elements are valid. Results of monitoring and evaluation will form the basis for modifying and refining evaluation techniques in the future.

Monitoring and evaluation are separate, sequential activities that provide information to determine whether CWE susceptibility modeling and evaluation are meeting their intended objectives. Monitoring collects information, on a sample basis, from specified sources. Evaluation of monitoring results is used to determine the effectiveness of CWE evaluations and the need to modify model elements. Monitoring is conducted at three distinct levels: implementation, effectiveness and validation.

24.1 - Implementation Monitoring. Conduct implementation monitoring as part of routine assignments and document the results in management files. Use implementation monitoring to determine if plans, prescriptions, projects and activities are implemented as designed and in compliance with appropriate environmental documents.

24.2 - Effectiveness Monitoring. Determine the effectiveness of CWE susceptibility analysis for reducing and maintaining the risk of adverse CWE to acceptable levels. Effectiveness monitoring determines if plans, prescriptions, projects and activities are effective in meeting management direction, objectives, and standards and guidelines. Conduct effectiveness monitoring after determining that plans, prescriptions, projects and activities have been reasonably implemented.

24.3 - Validation Monitoring. Conduct validation monitoring when effectiveness monitoring results indicate basic assumptions or coefficients are questionable. Validation monitoring determines whether the initial data, assumptions, and coefficients used in development and implementation of the model are correct or if there are better ways to meet the objectives.

## 25 - IMPLEMENTATION

25.1 - Organizational Structure. CWE assessments are conducted within a tiered organizational framework. This framework consists of three levels that interact and provide for continuity of application between forests, development of disturbance coefficients and other factors based on local experiences, and the latitude necessary for assessments to be sensitive to local conditions.

## SOIL AND WATER CONSERVATION HANDBOOK

The three organizational levels are Regional, Sub-regional and Forest. Team composition is interdisciplinary at each level. Individuals serve on the Regional and Sub-regional teams at the request of the Regional CWE Coordinator, with approval of their line officer.

1. Regional Team. The Regional Team is administered by the Regional Office, Range and Watershed Management (RO-RWM). It provides Regional direction and assists the Sub-regions and forests in conducting CWE assessments. It also provides quality control and assures that necessary interaction occurs between the Sub-regional Groups.

The Regional CWE Coordinator, RO-RWM, and one member from each of the Sub-regional Groups comprise the Regional Team.

2. Sub-Regional Groups. The three Sub-regional Groups bring together forests having broadly similar geomorphic and climatic characteristics and experiencing similar land management activities. The purpose of each of these groups is to modify the Regional Methodology, as required, to reflect sub-regional variations and to guide implementation and monitoring within its respective Sub-region.

The Sub-regional Group is the primary support group for any individual forest requiring assistance in analyzing CWE. The Regional CWE Coordinator provides technical and administrative consultation to each of the Groups.

Exhibit 1 lists the forests that make up each of the Sub-regional groups. Some forests are in two groups because they are located in a transition zone between two adjacent groups.

EXHIBIT 1

<u>SUB-REGIONAL GROUPS</u>		
<u>NORTHERN</u>	<u>CENTRAL</u>	<u>SOUTHERN</u>
Six Rivers	Plumas	Sequoia
Klamath	Tahoe	Angeles
Modoc	Eldorado	Los Padres
Shasta-Trinity	LTCMU	San Bernardino
Mendocino	Stanislaus	Cleveland
Plumas	Sierra	Inyo
Lassen	Sequoia	



## SOIL AND WATER CONSERVATION HANDBOOK

3. Forests. Forest Supervisors conduct CWE assessments for both forest-wide and project planning using concepts and procedures presented in this chapter. They are responsible for actively participating in their Sub-regional Group and for incorporating refinements developed by their Sub-regional Group into forest-specific CWE assessments.

Forest Supervisors conduct CWE assessments utilizing interdisciplinary teams composed of earth scientists and other required disciplines. These teams modify Sub-regional guidance to meet local requirements. They develop and utilize necessary watershed- and site-specific information regarding beneficial uses of water, watershed characteristics, and land disturbance factors that are sensitive for use in assessing CWE during project planning.

25.2 - Wild Fire. The following guidelines were developed following field review of large watershed areas burned on the Klamath, Shasta-Trinity, Mendocino and Stanislaus National Forests in the fall of 1987.

1. Evaluations should be consistent with existing Forest Plan direction and project planning procedures and techniques for assessing CWE.

2. Use available information to assist in evaluating CWE. Burned Area Reports (FSH 2509.13, Report FS-2500-A), and supporting data contain information valuable in evaluating the impacts resulting from the burns, as modified by emergency rehabilitation measures and treatments. These reports also contain estimates of watershed recovery.

3. Objectives for protection of beneficial uses of water do not change because an area has been burned. The ability to meet the objectives may be altered and, therefore, require extra care in planning Resource Recovery Programs and in identifying and implementing special mitigation efforts.

4. In watersheds approaching or exceeding Threshold of Concern (TOC) prior to burning, management direction for Resource Recovery efforts should be consistent with any management decisions made regarding CWE mitigation before the area was burned. In situations where management decisions are significantly different, it is important that information in EAs and other documents clearly present the methods and results of CWE analyses conducted, together with the rationale for changes in management direction.

## SOIL AND WATER CONSERVATION HANDBOOK

5. Most of the hillslope vegetation, organic ground cover and large organic debris in channels will be lost in areas of high burn intensity. These are the areas most susceptible to significant changes in watershed hydrology and sedimentation processes (surface erosion, landsliding and mobilization of stored sediment in stream channels, hydrophobic soils). Considerations beyond normal prescriptions are sometimes needed to mitigate adverse effects resulting from these changes.

6. Design and implement monitoring programs to evaluate the effectiveness of Resource Recovery Program (RRP) efforts in mitigating significantly adverse CWE.

7. The following steps will normally be used to evaluate CWE in watersheds that have been burned by wildfire:

a. Identify burned areas and downstream beneficial uses of water that may be adversely affected by the burns and RRP efforts.

b. Determine which watersheds to analyze. Base these determinations on burned areas, fire intensities, beneficial uses potentially at risk and other locally important factors.

In most cases, CWE analysis areas will be the same as those used for project-level CWE planning. In northwestern California, these are most often second- and third-order watersheds that typically range in size between 500 and 2,000 acres.

Some situations will also require analysis of CWE on larger watershed systems. It will be necessary to evaluate CWE for fourth- and fifth-order watersheds where an individual fire has extended across two or more second- or third-order watersheds, and when smaller fires have burned significant acreage in small, adjacent watersheds. Analysis of the larger watershed system can be done by aggregating information obtained from evaluating second- and third-order watersheds.

c. Determine pre-fire land disturbance history for each watershed and compare with the watershed's TOC. This information provides a pre-fire estimate of each watershed's susceptibility to significantly adverse CWE.

d. Evaluate current condition of burned areas. Variables to consider include burn intensity (high, moderate, low) and degree of modification of anticipated watershed impacts by implementing emergency rehabilitation treatments. High-intensity burn areas exhibit characteristics such as elimination of ground cover, loss of crown canopy, loss of riparian area vegetation, burning out of large organic material within channels, and hydrophobic soils.

## SOIL AND WATER CONSERVATION HANDBOOK

Moderate- and low-intensity burn areas exhibit increasingly less severe characteristics. For example, some riparian area vegetation may remain in moderate-intensity burn areas while nearly all may be retained in low-intensity burn areas.

e. Compare current condition of burned areas with:

(1) Site disturbance impacts from timber harvesting and site prep operations in similar terrain.

(2) Known effects of previous burns in similar areas.

Use this comparison to estimate burned area disturbance coefficients.

It is recommended that only a limited number of disturbance coefficients be developed. Three disturbance levels will normally be adequate for each terrain type within any given climatic regime (rain-dominated, rain-on-snow, snow-dominated). The coefficients should correspond to varying degrees of disturbance observed in the high, moderate and low intensity burned areas.

Preliminary surveys of some burned areas suggest that disturbance coefficients for high-intensity burn areas, as modified by emergency rehabilitation measures, will be equivalent to or somewhat higher than a typical clearcut/broadcast burn operation on similar ground. In contrast, many low intensity burned areas exhibit characteristics that are very similar to adjacent unburned areas. Disturbance coefficients would be very small, or zero, in these latter situations.

f. Estimate site recovery of burned areas, as modified by emergency rehabilitation work. This information is available in Burned Area Reports.

g. Use information developed in e. and f. of this section to estimate current watershed susceptibility to CWE. Use this information in environmental assessments of Resource Recovery opportunities and limitations.

8. Conduct CWE assessments for each alternative considered during Resource Recovery program planning. Information developed in e. and f. of this section, together with prior experience working in similar areas, should guide efforts to estimate site disturbance and recovery coefficients.

Preliminary evaluation of burned areas suggests that projected impacts of harvesting high-intensity burn areas may not add significantly to the overall impacts of the burns. This is especially so in areas with existing road systems. It is also anticipated that salvage operations

## SOIL AND WATER CONSERVATION HANDBOOK

in these areas will result in an overall disturbance coefficient being only slightly higher than that for normal harvesting operations, provided that needed additional mitigation measures are reasonably implemented.

25.3 - Northern Sub-Region. The following is a general summary of how the northern Sub-regional Group is evaluating CWE.

25.31 - Analysis Areas. Watershed sizes generally range between 20,000 and 50,000 acres for forest planning and between 500 and 2,000 acres for project planning.

25.32 - Natural Watershed Sensitivity. Natural watershed sensitivity is first estimated, based on geomorphic and climatic factors. These initial estimates are then modified to include consideration of the beneficial uses of concern. The result is an approximation of a watershed's ability to absorb land use impacts without causing unacceptable effects to beneficial uses of water.

For forest planning, the TOC generally ranges between 12 percent and 20 percent ERA depending upon the intrinsic sensitivity of the watershed and beneficial uses of water. Exhibit 1 contains examples of TOC values used in forest planning:

EXHIBIT 1

WATERSHED SENSITIVITY:	HIGH	TOC (%ERA)	
		MODERATE	LOW
FOREST			
Shasta-Trinity	12	16	18
Klamath	13	15	16

Threshold values for second- and third-order watersheds exhibit a greater range. Work on the Mendocino and Klamath National Forests has produced TOC values of 10 percent ERA for highly sensitive watersheds.

25.33 - Land Disturbance. Based on work conducted to date, alterations in watershed hydrology are believed to be the most probable mechanism for initiating adverse CWE on aquatic habitat. Site disturbance coefficients called equivalent road acres (ERA) have been developed to track general changes in the hydrologic functioning of watersheds. Development of the coefficients is done by comparing the effect of a land use activity to that of a road in terms of altering surface runoff patterns and timing.

## SOIL AND WATER CONSERVATION HANDBOOK

ERA coefficients have only been developed for roads and timber management activities; coefficients are being developed for other activities such as grazing and prescribed burns. To date the greatest amount of work has been done developing coefficients for forest planning. Exhibit 1 contains examples of coefficients used for forest planning:

EXHIBIT 1

<u>ACTIVITY</u>	<u>ERA COEFFICIENT RANGE</u>
Road Prism	0.80 - 1.0
Tractor Clear Cut	0.30 - 0.35
Cable Clear Cut	0.18 - 0.23

These coefficients take into account all timber management activities, including site preparation.

Forests have developed more refined coefficient estimates for project planning evaluations. For example, the Shasta-Trinity National Forests developed the set of ERA coefficients shown in Exhibit 2. These coefficients are modified, based on site specific analysis (Haskins, 1983):

EXHIBIT 2

<u>LOGGING SYSTEM</u>	<u>SILVICULTURE</u>	<u>ERA COEFFICIENT RANGE</u>
Tractor	Clearcut	0.20 - 0.30
	Overstory Removal	0.15 - 0.20
	Select	0.10 - 0.20
	Salvage	0.10
Cable	Clearcut	0.15 - 0.20
	Overstory	0.15 - 0.20
Helicopter	Clearcut	0.10
	Select	0.05

25.34 - Site Recovery. Recovery curves are divided into two major groups. The first group is used for forest planning. A 30 year, linear recovery period has generally been used in forest planning because of limitations in understanding recovery rates and the need to generalize during large area planning. Forests use other recovery curves as they deem appropriate.

## SOIL AND WATER CONSERVATION HANDBOOK

CHAPTER 10

Recovery curves for use in project planning constitute the second major group. There is considerably more variation in the shape and time for full recovery in this group of curves. Forest staff use professional judgement to develop curves that reflect local site conditions and operator performance in conducting the land disturbing activity.

## SOIL AND WATER CONSERVATION HANDBOOK

## CHAPTER 30 - STREAM PROTECTION-STREAMSIDE MANAGEMENT ZONES

Contents

## ZERO CODE

30.02

Objectives

30.03

Policy

31

STREAMSIDE MANAGEMENT ZONES (SMZ)

31.1

Size of SMZ

32

R-5 STREAM CLASSIFICATION SYSTEM

32.1

Implementation of Stream Classification





## SOIL AND WATER CONSERVATION HANDBOOK

CHAPTER 30 - STREAM PROTECTION-STREAMSIDE MANAGEMENT ZONES

30.02 - Objectives. The objective of stream protection is to ensure favorable conditions of water flow in regard to water quality, and to protect the environment commonly associated with streamcourses. This is accomplished by implementing resource management activities in a manner that maintains adequate soil and vegetative cover adjacent to perennial and intermittent streams.

30.03 - Policy. Stream protection guidelines will be developed when resource management activities are conducted adjacent to perennial streams and any intermittent streams that show signs of recurrent deposition or annual scour. Resource management prescriptions will employ protection measures sufficient to meet stream management objectives.

The R-5 stream classification system (section 32) will be used as an aid to identify the resource values and beneficial uses of streams, as an integral part of developing streamside management zone guidelines.

31 - STREAMSIDE MANAGEMENT ZONES (SMZ). Streamside Management Zone is a term used for areas given special management consideration adjacent to streams. SMZs are not intended to exclude resource management, but rather to stress the need for applying special care in management, in order to protect watershed values, as well as other resource values and beneficial uses of streams, while utilizing the commodity resources within the SMZ.

The area of special care in management, to be considered in the development of SMZ prescriptions, includes but is not limited to - riparian areas, floodplains, and intermittent streams showing signs of recurrent annual scour and/or deposition.

31.1 - Size of SMZ. Geographic size of the SMZ will vary depending on adjacent conditions of channels and sideslopes. Areas will be large enough to assure adequate protection, through special management attention, of the water resource from non point sources of pollution. During the development of SMZ guidelines, channel and slope stability will be considered to determine size of the SMZ. SMZ may include but are not limited to:

1. Stable channels. Characterized by few seasonal changes in the stream profile or cross-sectional area, and show little or no evidence of channel movement or active erosion by scouring or downcutting. Stable channels are composed of cohesive, durable, or resistant materials (solid rock, stone, or boulders). Deposition, if present, is usually limited to a high proportion of coarse materials.

## SOIL AND WATER CONSERVATION HANDBOOK

2. Unstable channels. Characterized by many seasonal changes in profile or cross sectional area, and show evidence of channel movement, or active erosion by scouring or downcutting. They are composed of friable, loose, or easily detachable, unconsolidated materials. The streambed is usually in a state of flux during periods of high streamflow. Deposition of fine materials in and near the streamcourse is common.

3. Stable side-slopes. Often characterized by the following conditions: low to moderate side-slopes (usually less than 30%); extensive vegetative cover; erect trees, not leaning or displaying pistol-butts; no evidence of landslide topography such as hummocks, swales, depressions, scars, transverse ridges, surface cracks, and fresh scars; good internal soil and rock drainage; not undercut by the streamcourse.

4. Unstable side-slopes. Usually characterized by any of the following conditions: moderately steep to steep side-slopes (usually greater than 30%); erosion hazard rating of 8-12; active and inactive landslides (surficial or deep seated); slopes at or greater than the natural angle of repose (70-75%); poorly consolidated or loose material such as soil, colluvium, talus, decomposed granite, or deeply weathered rock; rock structural features such as bedding planes, foliation planes, faults, joints, and fractures that dip at an angle which adversely affects the side-slope; slopes underlain by inherently weak materials such as plastic clays, clay shales, graphite schists, and altered serpentine; slopes with an unstable landscape condition described as P, S, Z, and U in the supplemental rating for unstable areas used in the Erosion Hazard Rating System.

An inner gorge is a geomorphic feature that requires special discussion in this unstable side slope section. An inner gorge is the innermost steep slopes of V-shaped drainages (normally in excess of 65%) marginal to stream channels. The inner gorge is generally separated from the upslope area by a break-in-slope.

The stream channel and side slopes of an inner gorge are so inter-connected that channel bank erosion is in effect undercutting the steep side slopes. Undercutting often removes the toe of the inner gorge side slopes causing mass wasting. Thus, inner gorges are inherently unstable, because slight changes in stream channel configuration can trigger mass wasting and subsequent high sediment loading.

## SOIL AND WATER CONSERVATION HANDBOOK

32 - R-5 STREAM CLASSIFICATION SYSTEM. Stream classification is a means of identifying resource values and beneficial uses associated with streams. Once values and uses are recognized, stream protection guidelines can be established for use in the planning and management of these lands. Within project areas, all streams and segments thereof must be classified.

Stream classification is based upon an evaluation of the following factors: (1) flow characteristics; (2) present and foreseeable instream and downstream values associated with waters of the stream; and (3) characteristics of the stream environment.

Flow characteristics need further definition, for such evaluation determines whether streams are perennial, intermittent, or ephemeral. Perennial streams normally flow year long, have well-defined channels, and often show signs of washing and scouring. Riparian or water-associated vegetation is usually present. Intermittent streams generally flow most of the year, but during the dry season they may cease to flow because of evapotranspiration and percolation losses. They may or may not support riparian vegetation. Litter is normally not present in the channels except during the fall of the year, indicating sufficient flow to move debris during the wet season. Ephemeral streams flow only in direct response to prolonged precipitation or melting snow. They are depressions in the ground surface and normally do not develop sufficient water to wash or scour; therefore, forest litter, vegetation, or both is usually present in the channel.

The stream classification system described below has been developed for Region-wide use. Each class establishes the relative importance or significance of a stream or segment thereof, based on resource values and beneficial uses. To use this classification, (1) compare a similar criteria described in each class, then (2) choose the one you consider most closely fits the local situation. This system is only a step in the process to get to the ultimate objective; that is, a detailed description of the ultimate protection measures needed.

1. Class 1, Highly Significant. These are either perennial or intermittent streams, or segments thereof, which meet one or more of the following criteria:

- a. Are habitat for large numbers of resident and/or migratory fish for spawning, rearing, or migration.
- b. Furnish water locally for domestic or municipal supplies.
- c. Have flows large enough to materially influence downstream water quality.

SOIL AND WATER CONSERVATION HANDBOOK

d. Are characterized by major fishing or other water-oriented recreational uses.

e. Have special classification or designation, such as wild, scenic, or recreation rivers.

f. Have special visual or distinctive landscape features, and are classified as variety Class A as defined in "National Forest Landscape Volume 2" (Agr. Handbook 462).

g. Are habitat for threatened or endangered animal species, or contain plants which are potential or viable candidates for threatened or endangered classification.

h. Exhibit ethnological, historical, or archaeological evidence that makes them eligible for, or are included in the "National Register of Historical Places."

2. Class II, Significant. These are either perennial or intermittent streams or segments thereof, which meet one or more of the following criteria:

a. Are used by moderate numbers of fish for spawning, rearing, or migration.

b. Furnish water locally for industrial or agricultural use.

c. Have enough water flow to exert a moderate influence on downstream quality.

d. Are used moderately for fishing and other recreational purposes.

e. Are of moderate visual quality and meet variety Class B as defined in "National Forest Landscape Management Volume 2" (Agr. Handbook 462).

f. Exhibit ethnological, historical, or archaeological evidence that makes them eligible for State or local registers of historical significance or interest.

3. Class III, Moderately Significant. These include perennial or intermittent streams, or segments thereof, which meet one or more of the following criteria:

a. Are habitat for few fish or spawning, rearing, or migration.

b. Are rarely used for fishing or other recreational purposes.

## SOIL AND WATER CONSERVATION HANDBOOK

- c. Have enough water flow to exert minimum influence on downstream water quality.
- d. Are of relatively low visual quality in the landscape and classified as variety Class B as defined in "National Forest Landscape Management Volume 2" (Agr. Handbook 462).
- e. Exhibit historical or archaeological properties that are of "archaeological interest" in accordance with the Archaeological Resource Protection Act of 1979.

4. Class IV, Minor Significance. These are intermittent or ephemeral streams, or segments thereof, not previously classified.

32.1 - Implementation of Stream Classification. Within land use planning units, those streams or segments thereof, which meet the criteria for Class I and II should be shown on land use planning maps; Classes III and IV can be displayed as percentage inclusions of capability areas in the forest data base.



## SOIL AND WATER CONSERVATION HANDBOOK

## CHAPTER 40 - RIPARIAN AREA MANAGEMENT

Contents

ZERO CODE

40.02

Objective

41

DELINEATION

42

INVENTORY AND ANALYSIS

43

PROTECTION AND IMPROVEMENT

43.1

Protection

43.2

Improvement





## SOIL AND WATER CONSERVATION HANDBOOK

CHAPTER 40 - RIPARIAN AREA MANAGEMENT

40.02 - Objective. The objective of this chapter is to set forth guidance for delineation; inventory and analysis; and protection and improvement of riparian areas.

41 - DELINEATION

1. Forest Planning. For land management purposes, identify and map down to units of two acres in size, or the level of resolution necessary to meet forest riparian area planning objectives.

2. Project Planning. Delineate riparian areas by on-site observation down to proportional parts of an acre, as necessary to meet forest riparian area management objectives. The unit of measure for riparian areas will be acres.

42 - INVENTORY AND ANALYSIS. A riparian area inventory is a compilation of specific physical and biological information gathered to describe the area, facilitate management decisions, and assess non-dependent resource production opportunities. Riparian inventory needs should be met through coordination of existing resource inventories to the extent practical, so as to avoid duplication of data and effort.

Two levels of riparian area inventories are possible:

1. Forest Land and Resource Management Planning. A riparian area inventory for forest planning should identify the quantity and quality of the riparian area resource and also the specific dependent resources in the various riparian areas. The Forest Supervisor or other individual with delegated responsibility shall determine the inventory intensity if standards for inventory have not been established by Regional direction.

Use inventory information for capability analysis, management alternative evaluation, land allocation, and the formulation of forest standards and guidelines for the management of riparian areas.

2. Project Planning. A riparian area inventory for project planning may be conducted as part of a multi or interdisciplinary review of resource management projects. Riparian area inventory data will serve as input to the environmental assessment, assist in the identification and formulation of mitigation measures, and guide the preparation of site-specific management recommendations. This information can also be used to refine the forest land management plans in subsequent planning cycles.

## SOIL AND WATER CONSERVATION HANDBOOK

The analysis processes shall allow the aggregation of forest riparian areas into homogeneous types for which specific resources can be identified, and management objectives and guidelines written.

43 - PROTECTION AND IMPROVEMENT. Riparian area protection and improvement needs will be identified as a result of inventory and analysis. Include these needs as a part of the riparian area management objectives.

43.1 - Protection. Riparian area protection measures shall be commensurate with the resource values identified for a particular stream/riparian area. Riparian area management recommendations shall be included, as needed, in project plans, environmental assessments, and environmental impact statements. Where applicable, require protective measures to be included in special use permits, timber sale, and other contracts.

As a minimum, consider the following when identifying protection needs in riparian areas.

1. Solar radiation is the prime cause of elevated stream temperature; therefore, water-surface shade canopy shall be maintained on streams where the maintenance of proper water temperatures is essential for the perpetuation of fish and aquatic habitat. In some cases, however, a fish biologist or hydrologist may determine that it is desirable to expose portions of a stream where water temperatures are too cold to provide optimum habitat for certain fish species. Shade canopy can be maintained by retaining those trees or shrubs that directly contribute shade to the water surface.

2. Adequate protection of riparian areas should include protection of the soil and vegetative cover, as well as the streamcourse itself. This may require adjustments in normal operating procedures, including appropriate modifications of road locations, silvicultural prescriptions, and use of heavy equipment.

3. Habitat capability models will describe habitat requirements which are to be provided/managed for MIS or riparian dependent wildlife species.

4. Merchantable trees within riparian areas may be harvested, provided their removal serves all management objectives.

5. Forage within riparian areas can be managed for grazing livestock, provided that prudent management practices for grazing are followed. Livestock grazing will be conducted in a manner designed to achieve riparian objectives for the area and to maintain streambank stability.

## SOIL AND WATER CONSERVATION HANDBOOK

6. Identify, evaluate, and protect prehistoric, historic, and ethnographic properties in accordance with FSM 2360 direction.

43.2 - Improvement

1. Improvement projects and management stipulations will be considered and accomplished through normal program and planning processes. Use any funding source, provided that use meets established criterion.



SOIL AND WATER CONSERVATION HANDBOOK  
CHAPTER 50 - SOIL EROSION HAZARD RATING

Contents

ZERO CODE

50.1	Authority
50.2	Objective
50.3	Policy
50.4	Responsibility
50.41	Forest Supervisors
50.42	District Rangers
50.5	Definitions
51	SHEET AND RILL EROSION HAZARD RATING (EHR) SYSTEM
51.1	Application
51.11	Projects
51.12	Reports
51.2	EHR Computation
51.3	Adjective Ratings
51.4	Erosion Hazard Reduction
52	GULLY EROSION HAZARD RATING (Reserved)
53	DRY RAVEL HAZARD RATING (Reserved)



SOIL AND WATER CONSERVATION HANDBOOK  
CHAPTER 50 - SOIL EROSION HAZARD RATING

50.1 - Authority. FSM 2501 lists the laws, regulations and Executive orders related to soil and water quality. See FSM 2510, 2520, 2530, and 2550, and FSH 2509.18 for Service-wide direction.

A memorandum of understanding (MOU), (FSM 1541.13) formalizes Forest Service coordination with the Soil Conservation Service relative to soil resources. The MOU includes reference to Forest Service participation in the National Cooperative Soil Survey. The California Soil Survey Committee is tiered to the National Cooperative Soil Survey (NCSS).

50.2 - Objective. To provide a standard method for evaluating erosion hazards and erosion control needs within Region 5 and with other agencies and individuals for similar lands and practices in California.

50.3 - Policy. Determine erosion hazard ratings (EHR's) for those actions that have a potential to cause accelerated erosion. Use the results of EHR evaluations to design projects and erosion control measures that are consistent with site specific soil and water quality objectives.

50.4 - Responsibility

50.41 - Forest Supervisors. Forest Supervisors shall:

1. Ensure the proper application of EHR's and erosion control measures to situations where there is a potential for accelerated erosion.
2. Monitor the effectiveness of the EHR system and work with the Regional Office, Range and Watershed Management Staff to determine if local or Regional adjustments in the system and its application are necessary.

3. Provide EHR training on a recurring basis for personnel involved in project planning, design and implementation.

50.42 - District Rangers. Each District Ranger shall:

1. Use EHR's in project planning to display the relative potential for planned actions and alternatives to cause accelerated erosion.
2. As indicated by EHR's, include appropriate erosion control measures in project design and implementation to the degree necessary to meet soil and water quality objectives.
3. Ensure that appropriate personnel involved in project planning and implementation receive EHR training.

## SOIL AND WATER CONSERVATION HANDBOOK

50.5 - Definitions

1. Erosion hazard. The likelihood or potential for accelerated erosion to occur.

2. Erosion hazard rating (EHR). A relative assigned risk for accelerated erosion to occur for a specific set of soil-site factors.

3. Erosion

a. The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.

b. Detachment and movement of soil or rock by water, wind, ice or gravity. The following terms are used to describe different types of water erosion:

(1) Accelerated erosion. Erosion much more rapid than natural, geological erosion, primarily as a result of the influence of the activities of humans, or in some cases, animals.

(2) Geological erosion. The natural erosion caused by geological processes acting over long geological periods. Synonymous with natural erosion.

(3) Gully erosion. The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 0.5 meter to as much as 25 to 30 meters.

(4) Interrill erosion. The removal of a fairly uniform layer of soil on a multitude of relatively small areas by splash due to raindrop impact and film flow.

(5) Natural erosion. Wearing away of the earth's surface by water, ice or other natural agents under natural environmental conditions of climate, vegetation, and the like.

(6) Rill erosion. An erosion process in which numerous small channels of only several centimeters in depth are formed.

(7) Sheet erosion. The removal of soil from the land surface by rainfall and surface runoff. Often interpreted to include rill and interrill erosion.

(8) Splash erosion. The detachment and airborne movement of small soil particles caused by the impact of raindrops on soils.



## SOIL AND WATER CONSERVATION HANDBOOK

## CHAPTER 50 - SOIL EROSION HAZARD RATING

51 - SHEET AND RILL EROSION HAZARD RATING (EHR) SYSTEM. Many land use activities have the potential to cause erosion rates to exceed natural soil erosion or soil formation rates. Examples include construction (for example, developments, roads and trails), timber harvesting, grazing, preparation for vegetation establishment, off-highway vehicle use, ski areas, mining, wildfires and prescribed burning. Potential consequences of accelerated erosion include reductions in the productive capacity of the soil and adverse effects on water quality. Many interrelated factors are evaluated in an EHR system to determine whether land use activities would cause accelerated erosion, and to what degree accelerated erosion would cause adverse effects.

Under the direction of the California Soil Survey Committee, an interagency task group developed this EHR system. The purpose of this effort was to provide a consistent method for use by different agencies and individuals that would help to:

1. Evaluate the likelihood that a specific soil disturbing activity would cause accelerated sheet and rill erosion.
2. Evaluate the relative risk for adverse consequences.
3. Identify approximate soil cover amounts needed to achieve an acceptable risk level.

This EHR system is a highly developed checklist and is not a mathematically exact equation. It is designed to appraise the relative risk of accelerated sheet and rill erosion. The system does not rate gully erosion, dry ravel, wind erosion, or mass wasting.

51.1 - Application. Use EHR's for project planning and implementation, site specific determinations, and in reports to reflect relative erosion hazards over large areas (for example, soil survey reports, forest plans and environmental documents). Slightly different techniques are used for these different applications.

51.11 - Projects. Make EHR's during early stages of activity planning to provide a means to predict relative post-activity erosion hazard conditions and to integrate necessary erosion control measures into project design. Different EHR's for a specific site are calculated by varying those factors that can be changed by the planned activity or by post-activity erosion control measures. This provides a comparison of the planned activity with alternative treatments and mitigation measures and permits selection of a desired post-activity erosion hazard. For example, a planned post-activity EHR is calculated to be high, but the desired rating is low. The soil cover factor can be adjusted until a low rating is achieved. The amount of soil cover needed to reduce the EHR to low is incorporated into the project design.

## SOIL &amp; WATER CONSERVATION HANDBOOK

For planned activities and site specific determinations, ratings are computed for representative, homogeneous units within an activity area. The climatic factor is constant over an activity area, but variations in soil, topographic and cover related factors may occur.

Changes in soil cover and topography are generally easy to detect. Whereas, changes in soil related factors are more difficult to detect, but can be anticipated by changes in topography, vegetation, rock fragments, soil color and other surface soil conditions. Soil maps can serve as a guide to variations in soil related factors.

A new rating is calculated where changes are noted because adjustments in planned treatments or mitigation measures may also coincide with these changes.

51.12 - Reports. Some EHR factors are "standardized" when the system is used to rate relative erosion hazards in soil survey reports, soil management reports, forest plans and other environmental documents. The soil cover factor is assumed to be constant to allow comparison of relative erosion hazards among different mapped areas. The "maximum" erosion hazard, obtained by assuming zero percent organic cover (living and dead), is used in this way to clearly display the risks of removing soil cover. The amount of soil cover needed to reduce erosion hazards to desired risk levels can also be given in the report, or report users can determine the required amount by adjusting the report "maximum" EHR with different soil cover percentages. Only the organic component of soil cover is adjusted to zero percent, whereas, surface rock fragments are still rated for soil cover. Variations in other EHR factors can be accommodated by using ranges or central values. The reports should describe EHR adjustments and use of EHR factors.

Rate each soil within a map unit separately. Overall ratings for soil map units that contain soils with different ratings are also necessary. Map units containing multiple soils with different EHR's can be rated in different ways (for example, using the most limiting rating, weighted averages based on component percentages, or ratings that represent different mixes). Describe these adjustments in the reports.

51.2 - EHR Computation. Use form R5-2500-14, Computation of Erosion Hazard Rating (ex. 1) to calculate EHR's. Exhibit 2 contains instructions for completing the form. The numbers, letters and titles used in the instructions correspond to those on the form.

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 1

USDA - Forest Service (Ref: FSH 2509.22)

California Soil Survey Committee

## COMPUTATION OF EROSION HAZARD RATING (EHR)

Sheet and Rill Erosion

								Alternative																
<b>I. SOIL ERODIBILITY FACTORS</b>																								
A. TEXTURE (from table 1 in instructions)																								
B. AGGREGATE STABILITY ADJUSTMENTS (see instructions)																								
C. SOIL ERODIBILITY RATING = Sum of A + B																								
<b>II. RUNOFF PRODUCTION FACTORS</b>																								
A. CLIMATE (2 year, 6-hour precipitation).																								
Inches	<1.0	1.0 - 1.7	1.8 - 2.2	2.3 - 2.7	>2.7																			
Rating	1	2	3	4	5																			
B. WATER MOVEMENT IN THE SOIL:																								
Infiltration	Rapid	Rapid	Rapid	Moderate	Rapid or Moderate	Rapid or Moderate	Slow																	
Permeability	Any	Moderate	Moderate	Any	Slow	Slow	Any																	
RL Depth (in)	>40	20-40	<20	>40	20-40	<20	Any																	
Rating	1	2	3	3	4	6	8																	
C. RUNOFF FROM ADJACENT AND INTERMINGLED AREAS:																								
Amount	Low		Moderate		High																			
Rating	0		2		5																			
D. UNIFORM SLOPE LENGTH:																								
Length (ft)	<25		25 - 50		>50																			
Rating	1		3		6																			
E. RUNOFF PRODUCTION FACTOR = Sum of A + B + C + D																								
F. RUNOFF PRODUCTION RATING = Runoff Production Factor divided by 3																								
<b>III. RUNOFF ENERGY RATING = Slope percent divided by 100</b>																								
<b>IV. SOIL COVER FACTORS</b>																								
A. QUANTITY AND QUALITY (From table 2 in instructions)																								
B. COVER DISTRIBUTION: Uniform = 0      Patchy = 1																								
C. SOIL COVER RATING = Sum of A + B																								
<b>V. RATINGS PRODUCT = Product of Ratings I x II x III x IV</b>																								
<b>VI. ADJECTIVE RATING = From table below</b>																								
<table border="0"> <tr> <td>&lt;4</td> <td>LOW</td> <td>Soil/Stop</td> <td>_____</td> </tr> <tr> <td>4 - 12</td> <td>MODERATE</td> <td>Project/Location</td> <td>_____</td> </tr> <tr> <td>13 - 29</td> <td>HIGH</td> <td>Name/Date</td> <td>_____</td> </tr> <tr> <td>&gt;29</td> <td>VERY HIGH</td> <td></td> <td></td> </tr> </table>								<4	LOW	Soil/Stop	_____	4 - 12	MODERATE	Project/Location	_____	13 - 29	HIGH	Name/Date	_____	>29	VERY HIGH			
<4	LOW	Soil/Stop	_____																					
4 - 12	MODERATE	Project/Location	_____																					
13 - 29	HIGH	Name/Date	_____																					
>29	VERY HIGH																							

Destroy Previous Editions

R5-2500-14 (2/90)

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 1 -- continued

**ABBREVIATED INSTRUCTIONS FOR EROSION HAZARD RATING COMPUTATION**  
(See FSH 2509.22, Chapter 50 for detailed instructions)

**I.A. - TEXTURE.**

TEXTURAL CLASS	SLOPE STEEPNESS			
	0-15%	16-30%	31-45%	46-60%+
Sand	1	1	2	3
Loamy Sand	1	2	3	3
Sandy Loam	2	2	3	3
Sandy Clay Loam	2	2	3	3
Sandy Clay	1	1	1	1
Clay	1	1	1	1
Clay Loam	2	2	2	2
Loam	3	3	3	3
Silty Clay	2	2	2	2
Silty Clay Loam	3	3	3	3
Silt Loam	4	4	4	4
Silt	4	4	4	4

**I.B. - AGGREGATE STABILITY ADJUSTMENTS.**

When sodium content decreases aggregate stability use +1. When iron, structure, organic matter, or rock fragments (not surface) increases aggregate stability Use -1. Soil erodibility factor is never adjusted to 0.

**II.A. - CLIMATE.** Values from map or local station data.**II.B.1. - INFILTRATION OF THE SURFACE SOIL.**

**Rapid.** Sands, loamy sands, sandy loams, and porous fine sandy loams and loams; generally very porous. >2 in/hr.

**Moderate.** Loams, silt loams and friable clay loams; also includes, the more porous soils of finer textures, and the less porous soils of coarser textures. 0.6 to 2.0 in/hr.

**Slow.** Clay loams and clays that are firm, sticky and plastic; generally, with very few pores. <0.6 in/hr.

Compensate as needed for compaction and hydrophobicity. Adjust to next slower class(s) depending upon severity of reduced infiltration.

**II.B.2. - PERMEABILITY OF THE SUBSOIL.**

Soil, rock or other kinds of layers within 40 inches of the soil surface are evaluated.

**Soil**  
**Rapid.** Sands, loamy sands, sandy loams & fine sandy loams: very porous. (>2 in/hr)

**Moderate.** Loams, silt loams & friable clay loams: porous. (0.6 to 2.0 in/hour)

**Slow.** Clay loams & clays that are firm, sticky & plastic: few or very few larger pores. (<0.6 in/hour)

**Nonsoil Material**  
Fractured or loose material. Water movement not impeded.

Fractured or weathered material can be dug with a shovel.

Very few widely spaced fractures. Weathered material usually is dense.

**II.B.3. - RESTRICTING LAYER (RL) DEPTH.**

Depth to layer that is rated for subsoil or substrata permeability. Includes subsoil layers, cemented layers, clay layers, compacted layers, and weathered or unweathered rock. Shallow soils over highly fractured bedrock that are permeable to water are not considered to be shallow.

**II.C. - RUNOFF FROM ADJACENT AND INTERMINGLED AREAS.**

Includes rock outcrop, soil areas with water movement (II. B.) factors totaling 6 or more, and disturbed areas (compacted areas, roads, and developed areas).

**Low.** Less than 15 percent of adjacent or intermingled areas contain impervious or nearly impervious surfaces.

**Moderate.** Between 15 and 50 percent of adjacent or intermingled areas contain impervious or nearly impervious surfaces.

**High.** More than 50 percent of adjacent or intermingled areas contain impervious or nearly impervious surfaces.

**II.D. - UNIFORM SLOPE LENGTH.** Distance that occurs before a significant change in water movement or flow direction may take place.

**III. - RUNOFF ENERGY.** Slope percent divided by 100 and rounded to nearest hundredth.

**IV. SOIL COVER****IV.A. - QUANTITY AND QUALITY.**

Amount of surface area covered by low growing vegetation (grasses, forbs, and prostrate shrubs), plant litter and debris, and surface rock fragments larger than about 3/4 inch. Shrub and tree cover is amount of area covered by their canopies.

**PERCENT GROUND COVER**

PERCENT SHRUB & OR TREE CANOPY	0-10	11-30	31-50	51-70	71-90	>90
0 - 10	5	4	3	2	1	0
11 - 30	4	4	3	2	1	0
31 - 50	4	3	3	2	1	0
51 - 70	3	3	3	2	1	0
71 - 90	3	3	2	2	1	0
>90	3	2	2	1	0	0

**IV.B. - COVER DISTRIBUTION.**

Uniform if more than 50 percent of an area is within one of the percent ranges listed above.

Patchy if more than 50 percent of an area falls outside a single percent-age range.

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 2

## INSTRUCTIONS

California Soil Survey Committee  
 EROSION HAZARD RATING (EHR) SYSTEM  
 FOR  
SHEET AND RILL EROSION  
 July 1989

## I. SOIL ERODIBILITY FACTORS

## A. Texture.

Surface soil textural classes and slope steepness are used to identify relative soil erodibility factors. Soil texture class erodibility factors for the 0-15 percent slope group are based on textural components of the Universal Soil Loss Equation K-value calculation, and are adjusted to compensate for particle size class transport differences due to increasing slope gradient. Select the numerical rating for the appropriate surface texture and slope grouping from Table 1.

Table 1: Relative Soil Texture Erodibility Factors

Textural Class	Slope Steepness			
	0-15%	16-30%	31-45%	46-60%+
Sand	1	1	2	3
Loamy sand	1	2	3	3
Sandy Loam	2	2	3	3
Sandy clay loam	2	2	3	3
Sandy clay	1	1	1	1
Clay	1	1	1	1
Clay loam	2	2	2	2
Loam	3	3	3	3
Silty clay	2	2	2	2
Silty clay loam	3	3	3	3
Silt loam	4	4	4	4
Silt	4	4	4	4

## Soil Erodibility Factor Descriptors:

1 - Low      2 - Moderate      3 - High      4 - Very high

## B. Aggregate Stability Adjustments.

Soil characteristics other than texture can also increase or decrease aggregate stability. These may be the result of unique conditions where adjustments are best made based on local experience or measurements.

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 2 -- Continued

Sodium affected soil can have less aggregate stability than texture alone would indicate. Soil survey reports serve as a guide to the occurrence of sodium affected soils. When sodium content is considered to be a factor that lessens aggregate stability, the adjustment factor is +1.

Soils high in iron tend to have greater aggregate stability than texture alone would indicate. This characteristic has been associated with soils classified with oxidic family modifiers. Soil survey reports serve as a guide to the occurrence of these soils. Other soil characteristics can also significantly influence or be indicative of increased aggregate stability. These include visibly strong soil structure, organic matter, and rock fragment content. Rock fragment content in this context refers only to conditions where rock fragments directly affect aggregate stability. Rock fragment content that provides protection from raindrop impact is rated as a component of soil cover.

When soil characteristics occur that significantly increase aggregate stability, the adjustment factor is -1. However, the soil erodibility factor is never adjusted to zero.

C. Soil Erodibility Rating. Enter the sum of A. and B.

## II. RUNOFF PRODUCTION FACTORS

### A. Climate.

The 2-year, 6-hour precipitation map (figure 1) is used as a guide to the relative occurrence of significant storm events. Values from the map are used to determine the rating. Larger scale maps are contained in "Precipitation Frequency Atlas of the Western United States," NOAA Atlas 2, Volume XI-California, U.S. Department of Commerce, 1973. More specific information for local areas may be used if available.

### B. Water Movement in the Soil.

Infiltration, permeability, and the depth to permeability reduction are inter-related factors that govern the rate of water movement into and through the soil. These factors are evaluated together to account for interactions among the factors.

1. Infiltration of the surface soil. Infiltration is the rate of water movement into the soil. Either existing or post activity soil conditions are used to determine the likelihood of producing surface runoff. Use the following soil texture, porosity and consistence descriptions as a guide to rating undisturbed conditions.

Rapid. Sands, loamy sands, sandy loams, and porous fine sandy loams and loams; generally very porous. (>2 inches/hour).

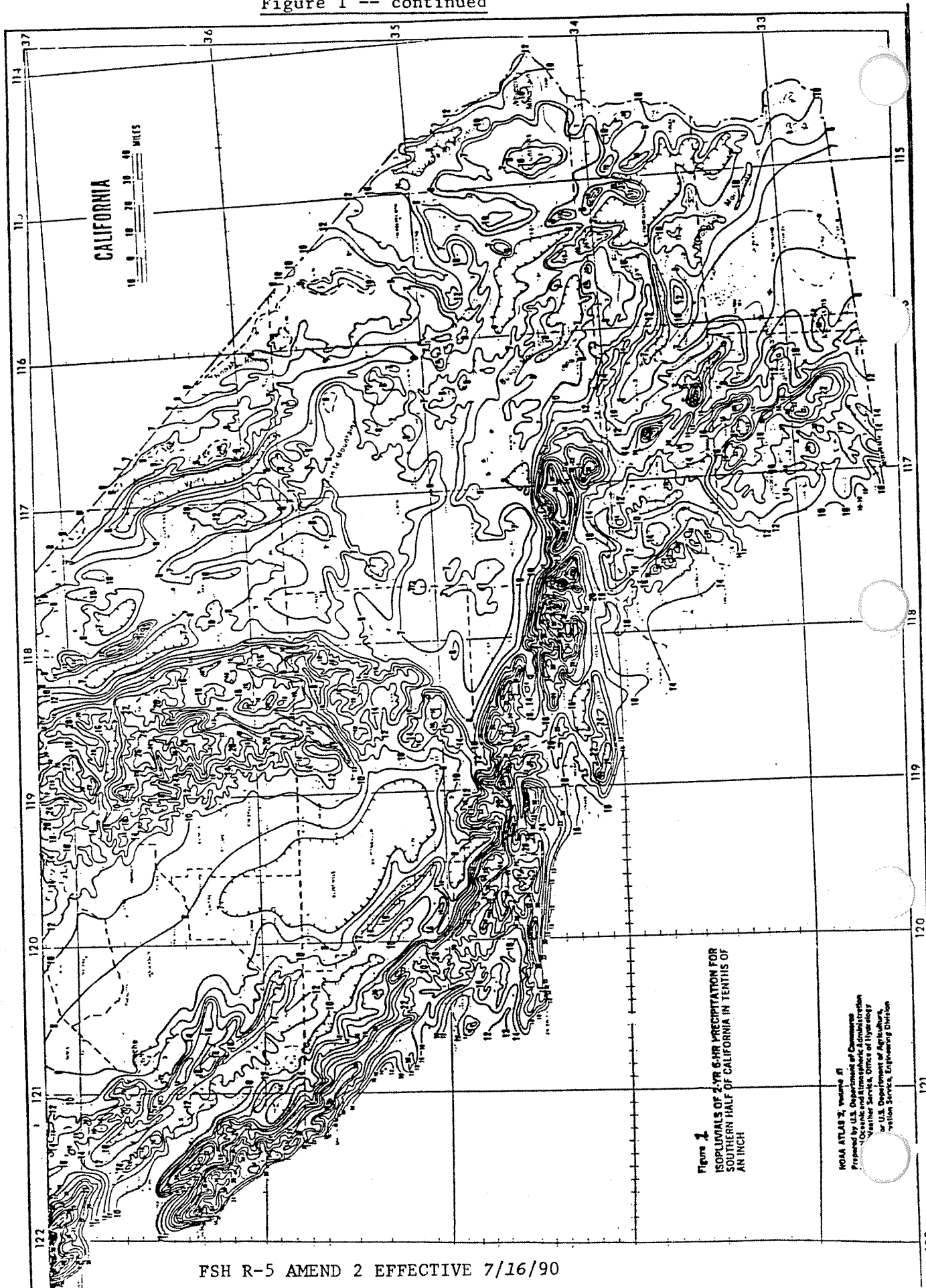
## SOIL AND WATER CONSERVATION HANDBOOK

Figure 1



## SOIL AND WATER CONSERVATION HANDBOOK

Figure 1 -- continued





## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 2 -- continued

Moderate. Loams, silt loams and friable clay loams; also includes, the more porous soils of finer textures, and the less porous soils of coarser textures. (0.6 to 2.0 inches/hour).

Slow. Clay loams and clays that are firm, sticky and plastic; generally with very few continuous pores. (<0.6 inches/hour).

Infiltration rates can be reduced by various management activities. This may be the result of compaction by equipment or animal use on nearly dry or moist soils; puddling from equipment or animal use on wet soils; puddling caused by raindrop impact on bare soils with loam or finer textures and relatively low organic matter content; or hydrophobic conditions caused by fire (some forest soils very high in organic matter are also naturally hydrophobic when dry).

Existing soil conditions and the potential effects of planned activities on infiltration rates should be evaluated to determine if the natural soil rating needs to be modified. Surface soil indicators of reduced infiltration potential include platy soil structure and soil pores that are mostly spherical or discontinuous.

Ratings should be adjusted to the next slower class depending upon the severity of reduced infiltration.

2. Permeability of the subsoil. Permeability is the rate at which water moves down through the soil. The permeability of rock or other kinds of layers within 40 inches of the soil surface are also evaluated here. Subsoil and substrata permeability rates are compared to surface infiltration rates to evaluate the likelihood of water accumulating in the soil. A restricting layer should have a permeability rating that is at least one class slower than the surface infiltration rating. Use the following descriptions as a guide to the ratings.

	<u>Soil</u>	<u>Nonsoil Material</u>
<u>Rapid</u>	Sands, loamy sands, sandy loams, and fine sandy loams; generally very porous. (>2 inches/hour).	Highly fractured or loose material. Water movement is not impeded.
<u>Moderate</u>	Loams, silt loams, and friable clay loams; also includes the more porous soils of finer textures, and the less porous soils of coarser textures. (0.6 to 2.0 inches/hour).	Fractured or weathered material that can be dug with a shovel.

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 2 -- continued

<u>Slow</u>	Clay loams and clays that are firm, sticky & plastic; generally with very few pores. (<0.6 inches/hour).	Very few widely spaced fractures. Unweathered or weathered materials are dense.
-------------	--	---

3. Restricting Layer (RL) Depth. The depth from the soil surface to the layer rated as restricting the downward movement of water. This includes subsoil layers, cemented layers, clay layers, compacted layers, and weathered or unweathered rock. Shallow soils over highly fractured bedrock that is permeable to water are not considered to be shallow for these purposes.

Soil depth and the nature of subsurface materials can be observed in road cuts and small soil pits.

C. Runoff from Adjacent and Intermingled Areas.

The amount of, and proximity to, impervious or nearly impervious surfaces can increase the production of surface runoff. Impervious or nearly impervious surfaces include rock outcrop, floodplains, soil areas with water movement (II. B.) factors totaling 6 or more, and severely disturbed areas (e.g., compacted areas, roads, and developed areas). This factor allows for rating complex soil patterns and miscellaneous areas. Use the following as a guide to the ratings.

Low. Less than 15 percent of adjacent or intermingled areas contain impervious or nearly impervious surfaces.

Moderate. Between 15 and 50 percent of adjacent or intermingled areas contain impervious or nearly impervious surfaces.

High. More than 50 percent of adjacent or intermingled areas contain impervious or nearly impervious surfaces.

D. Uniform Slope Length.

Slope length and surface variation are used to reflect the magnitude of slope gradient effects on surface runoff. The surface microrelief is evaluated by the distance between significant changes in water movement or flow direction (e.g., the distance between intercepting ground cover, benches, mounds, flats and other soil surface features).

E. Runoff Production Factor. Enter the sum of A., B., C. and D.

F. Runoff Production Rating. Divide the Runoff Production Factor by 3 and round to the nearest tenth. (Division by three is used to keep the rating in a numeric range that reflects the importance of runoff production relative to the other rating factors).

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 2 -- continued

## III. RUNOFF ENERGY FACTOR

Slope gradient is used to represent the relative sediment transport capacity of surface runoff. The runoff energy rating is the measured percent slope divided by 100 and rounded to the nearest hundredth (keep two decimal points). For example, 35 percent slope is recorded as .35. Use .01 for slopes less than 1 percent.

## IV. SOIL COVER FACTORS

## A. Quantity and Quality.

Ground cover is more effective than shrub or tree cover in resisting the erosive effects of raindrop impact and surface runoff. Table 2 accounts for these differences. Ground cover is based on the amount of surface area covered by low growing vegetation (grasses, forbs, and prostrate shrubs), plant litter and debris, and surface rock fragments larger than about 3/4 inch (3/4 inch is used because smaller rock fragments are displaced by raindrop impact and it coincides with Soil Conservation Service Soil Interpretation Record data, SCS SOI-5). Shrub and tree cover is based on the proportion of the ground surface covered by their canopies. Select the rating number that coincides with the appropriate percentages of ground cover versus shrub and/or tree cover.

Table 2: Soil Cover Factors.

## GROUND COVER

Percent		0 - 10	11 - 30	31 - 50	51 - 70	71 - 90	>90
SHRUB AND/ OR TREE CANOPY	0 - 10	5	4	3	2	1	0
	11 - 30	4	4	3	2	1	0
	31 - 50	4	3	3	2	1	0
	51 - 70	3	3	3	2	1	0
	71 - 90	3	3	2	2	1	0
	>90	3	2	2	1	0	0

Soil cover is often difficult to consistently estimate. For comparison, subtract estimated bare soil from 100 to help evaluate soil cover estimates.

## B. Cover Distribution

This rating compensates for variations in the continuity of soil cover. For example, an area may have a live tree canopy that is consistently between 30 and 50 percent, but the ground cover is mostly "patchy" (i.e., 70 to 100 percent in part of the area and 50 to 70 percent in other parts). Patchy areas are too small to stratify as separate hazard rating areas.

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 2 -- continued

Soil cover is considered to be uniform if more than half of an area is consistently within one of the percent ranges listed in Table 2. The cover is considered patchy when more than half of an area falls outside a single percentage range.

C. Soil Cover Rating. Enter the sum of A. and B.

## V. RATINGS PRODUCT.

Multiply ratings for I, II, III and IV; then round to the nearest whole number.

## VI. ADJECTIVE RATING

Ranges of ratings products are assigned adjective ratings as follows:

<u>Numeric Rating</u>	<u>Adjective Rating</u>
<4	Low
4 - 12	Moderate
13 - 29	High
>29	Very high

Numeric ratings near group transitions should be re-evaluated to verify rating. Descriptions of adjective rating groups and their interpretation is contained in section 51.3.

## SOIL AND WATER CONSERVATION HANDBOOK

51.3 - Adjective Ratings. Numeric ratings are placed into adjective groups of low, moderate, high and very high to aid application and communication. Areas with numeric values within the range of each adjective rating group, generally have similar accelerated erosion risks and consequences if corrective measures are not applied.

The adjective EHR's are described in terms of the likelihood and consequences of accelerated erosion. This reference can be made by comparing the EHR for natural cover and soil conditions with the EHR for the present condition or a planned treatment. As the risk of accelerated erosion increases, so does the likelihood that accelerated erosion will exceed soil formation rates. The risk and consequences become especially critical for shallow and moderately deep soils over consolidated materials.

The ratings are based on the long-term average occurrence of 2-year, 6-hour storm events. Erosion hazard risks are greater when storm frequency, intensity and/or duration exceed long-term average occurrence, and risks are less when occurrence is below "average". The following describes the risks and consequences for adjective EHR's:

Low EHR (less than 4 numeric rating). Accelerated erosion is not likely to occur, except in the upper part of the low EHR numerical range, or during periods of above average storm occurrence. If accelerated erosion does occur, adverse effects on soil productivity and to nearby water quality are not expected.

Erosion control measures are usually not needed for these areas.

Moderate EHR (4 to 12 numeric rating). Accelerated erosion is likely to occur in most years. Adverse effects on soil productivity (especially to shallow and moderately deep soils) and to nearby water quality may occur for the upper part of the Moderate EHR numerical range, or during periods of above average storm occurrence.

Evaluate the need for erosion control for these areas. A wide selection of measures and application methods are available.

High EHR (13 to 29 numeric rating). Accelerated erosion will occur in most years. Adverse effects on soil productivity (especially to shallow and moderately deep soils) and to nearby water quality are likely to occur, especially during periods of above average storm occurrence.

Erosion control is necessary for these areas to prevent accelerated erosion. The selection of measures and methods of application are somewhat limited.

Very high EHR (more than 29 numeric rating). Accelerated erosion will occur in most years. Adverse effects on soil productivity and to nearby water quality are very likely to occur, even during periods of below average storm occurrence.

## SOIL AND WATER CONSERVATION HANDBOOK

Erosion control is essential for these areas to prevent accelerated erosion. The selection of measures and methods of application are limited.

51.4 - Erosion Hazard Reduction. Runoff production and soil cover are erosion hazard factors commonly altered by soil disturbing activities. EHR's can be reduced by compensating for the affects of planned activities on these factors, or by applying mitigation measures after an activity or to an existing condition.

For example, reduce moderate, high or very high erosion hazards to desired risk levels by leaving or adding appropriate kinds and amounts of soil cover. Approximate this by calculating EHR's with different amounts of soil cover (Part IV of EHR computation) to reach the desired rating.

Existing organic matter (living and dead) on a site is the common source of adequate soil cover. This includes forage residues on rangeland and logging residues on forestland.

If adequate soil cover is not available on a site, it can be added using a variety of different materials. These include, wood fiber (hydro-mulch), straw, wood chips, netting, seeding with rapid growing erosion control plants, and establishing permanent vegetative ground cover (for example, ski slopes and other severely disturbed areas).

Tillage can alleviate reduced infiltration and increased surface runoff caused by activity related compaction.

Shortening the slope length factor is another means of reducing the erosion hazard. Techniques include, terracing, contour tillage and windrowing organic materials on the contour.

Use EHR's to guide cross-drainage spacing needs for linear areas that generate surface runoff (for example, unsurfaced roads, fire lines, and trails). Exhibit 1 contains guidelines for cross-drainage spacing.

The cost of installing effective erosion control measures usually increases as EHR's increase. Although erosion control measures are commonly a cost effective means of avoiding adverse effects, the cost effectiveness and ability to implement erosion control measures on areas with very high EHR's deserves careful evaluation. Planning activities to retain enough existing soil cover is often the most cost effective means of meeting a desired level of erosion hazard risk with the least adverse effects.

## SOIL AND WATER CONSERVATION HANDBOOK

Exhibit 1

## CROSS-DRAINAGE SPACING GUIDE

Cross-drainage (also referred to as water bars, water breaks or dips) is constructed on unsurfaced roads, trails, fire lines and other linear areas to control erosion of these surfaces and adjacent areas. Cross drainage for permanent roads and trails should be included in their design.

CROSS-DRAINAGE SPACING (feet) 1/

Road or Trail Gradient (%)	Erosion Hazard Rating for Area <u>2/</u>			
	Low <4	Moderate 4 - 12	High 13 - 29	Very High >29
4 - 6	400	350	300	250
7 - 9	300	250	200	150
10 - 14	200	175	150	125
15 - 20	150	120	90	60
21 - 40	90	70	50	30
41 - 60	50	40	25	15

1/ Spacings are measured with the slope.

2/ EHR's are based on general area immediately below the road or trail.

This table is a guide. Judgement is needed to adapt cross-drainage spacing and location to meet specific onsite conditions. In addition to proper spacing, cross-drains should discharge onto areas protected by vegetative cover, organic debris or coarse rock fragments. They should also be located to promptly intercept run-off from lateral roads, trails or other areas that may concentrate water run-off.

